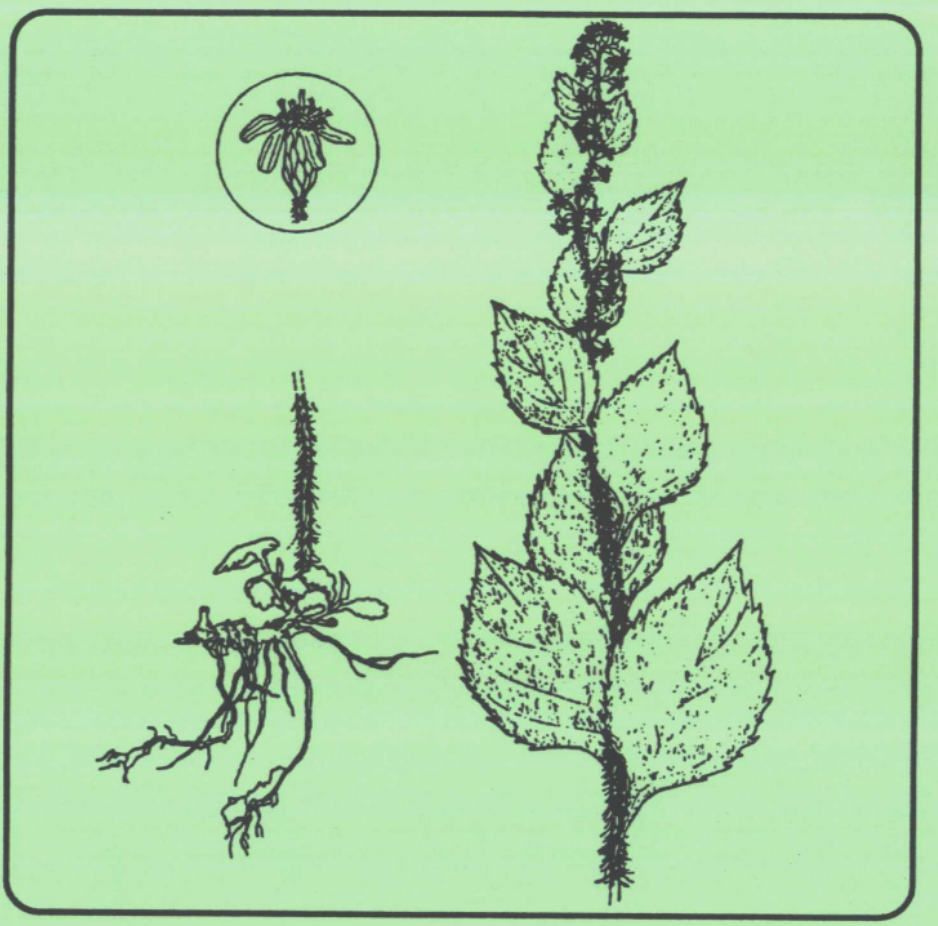
Recovery Plan

White-haired Goldenrod

(Solidago albopilosa)



U.S. Fish and Wildlife Service

RECOVERY PLAN

for

White-haired goldenrod (*Solidago albopilosa*)

Prepared by

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for

Southeast Region
U.S. Fish and Wildlife Service
Atlanta, Georgia

Approved: _____
James W. Pulliam, Jr.
Regional Director, U.S. Fish and Wildlife Service

Date: September 28, 1993

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Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1993. White-haired Goldenrod Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, GA. 46 pp.

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EXECUTIVE SUMMARY

Current Status: *Solidago albopilosa* (white-haired goldenrod) is listed as a threatened species by the U.S. Fish and Wildlife Service and is considered endangered within the Commonwealth of Kentucky by the Kentucky Academy of Science and the Kentucky State Nature Preserves Commission. The 90 known occurrences of the species are found in three counties in Kentucky. All occurrences are within the proclamation boundaries of the Daniel Boone National Forest. Many occurrences are in heavily traveled areas and are very vulnerable to disturbance.

Habitat Requirements and Limiting Factors: White-haired goldenrod grows in sandy soil behind the drip line of sandstone rock-shelters and on rock ledges. It is very rarely found in open sunlight and is never found in the darkest recesses of rock-shelters. The most serious threats to the species are trampling by hikers and campers and digging by archaeological looters.

Recovery Objective: To delist the species.

Recovery Criteria: White-haired goldenrod will be considered for delisting when there are at least 40 self-sustaining, protected occurrences that have been maintained for 10 years. An occurrence will be considered to be self-sustaining if it is observed to be reproducing and the population size is stable or increasing. An occurrence will be considered protected if all necessary management techniques are being used to protect the species at that location.

Actions Needed: (1) Protect at least 40 occurrences; (2) continue inventory; (3) study life history/ecological requirements; (4) maintain plants and seeds *ex situ*.; and, (5) conduct education programs.

Costs ($1,000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1994	110.80	34.50	21.75	7.20	0.75	175.00
1995	29.70	3.00	3.50		0.75	36.95
1996	29.70		2.00		0.75	32.45
1997	7.20		0.75		0.75	8.70
1998	7.20		0.75		0.75	8.70
1999	7.20		0.75		0.75	8.70
2000	7.20		0.75		0.75	8.70
2001	7.20		0.75		0.75	8.70
2002	7.20		0.75		0.75	8.70
2003	7.20		0.75		0.75	8.70
TOTAL:	220.60	37.50	32.50	7.20	7.50	305.30

Date of Recovery: By the year 2004, if funds are available to implement needed recovery actions.

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PART I

INTRODUCTION

General Information

White-haired goldenrod (*Solidago albopilosa*) is found in Menifee, Powell, and Wolfe Counties in east-central Kentucky. Endemic to Kentucky, the species grows behind the drip line of sandstone rock-shelters and on rock ledges. All occurrences of the species are found within the proclamation boundary of the Daniel Boone National Forest (DBNF), an area managed by the U.S. Forest Service (USFS). Most of the occurrences are on USFS land; however, a number of occurrences are on private inholdings within the DBNF. The term "occurrence" is used to refer to a discrete group of plants beneath a single rock-shelter or on a single rock ledge.

The very limited range of *S. albopilosa*, its specific habitat requirements, and the trampling of its habitat by visitors resulted in its listing as a federally threatened species on April 7, 1988 (U.S. Fish and Wildlife Service [Service] 1988). The Kentucky Academy of Science and Kentucky State Nature Preserves Commission consider *S. albopilosa* to be endangered in Kentucky (Warren et al. 1986).

Description

The long, soft, white hairs that cover the leaves and stems are a distinguishing characteristic of *S. albopilosa*. This rhizomatous perennial herb is decumbent or laxly spreading in its habit. Stems are slightly zigzagged, 2 to 5.5 decimeters long, terete, and grooved. The thin, soft leaves are alternate and are largest at the base; however, the lowermost leaves are usually absent at flowering. Leaves are ovate to elliptic, acute or acuminate, with subcordate bases and coarse, serrate margins. Leaf blades are 3 to 6 centimeters (cm) long and 3 to 5 cm wide. Hairs cover both surfaces of the leaves and are most dense along the veins. Petioles are one-half to one-third the length of the leaf blade and are scarcely winged to rounded. The inflorescence is composed of axillary clusters or is sometimes thyrsoid; however, the thyrse, when present, is poorly developed. Flower heads are composed of four or five (rarely three) ray florets (5 to 6.4 millimeter [mm] long) and more than 15 disk florets (3 mm long). The flowers are fragrant and bright yellow. The pale brown achene is 1.5 to 2.2 mm long, narrowly oblong, and covered with ascending silvery hairs. The fine, white pappus is about 3 mm long (Braun 1942, Gleason and Cronquist 1963, Fernald 1970, Andreasen and Eshbaugh 1973, Kral 1980). *Solidago albopilosa* is in the family *Asteraceae*; there are no synonyms for the species.

Solidago albopilosa is very similar to and thought to be derived from *S. flexicaulis* (broad-leaf goldenrod) (Braun 1942, Andreason and Eshbaugh 1973). *Solidago albopilosa* is shorter, has smaller and

thinner leaves, and is more densely hairy than *S. flexicaulis*. The habitats of the two species are also distinct. *Solidago albopilosa* is found behind the drip line of sandstone rock-shelters and on rock ledges, whereas *S. flexicaulis* is most commonly found growing on the limestone soils found in the Red River Gorge (Kral 1980, Harker *et al.* 1981, Francis *in litt.*).

Solidago albopilosa was first discovered by E. Lucy Braun in Menifee County, Kentucky, in 1940 and was described in 1942 (Braun 1942). The holotype is at the Gray Herbarium (GH, E.L. Braun 4278). Isotypes are at several herbaria, including the Gray Herbarium (two specimens), Missouri Botanical Garden (Missouri, two specimens), New York Botanical Garden (New York, one specimen), U.S. National Herbarium, Smithsonian Institution (Washington, D.C., one specimen), and the University of Cincinnati (CINCI, number of specimens unknown) (Medley 1980).

Distribution

The DBNF is within the Cliff and Cumberland Plateau Sections of the Appalachian Plateaus Physiographic Province of the United States (Fenneman 1938). The Appalachian Plateaus Physiographic Province has underlying Pennsylvanian rocks, primarily sandstones, but also has conglomerates, shales, and coal (Fenneman 1938). The Pottsville Escarpment, a belt of steep cliffs of Pennsylvanian sandstone, borders the western edge of the DBNF (Fenneman 1938). *Solidago albopilosa* is only found associated with Pennsylvanian sandstone outcrops that are a part of a rugged, highly dissected area known popularly as the Red River Gorge (Weir 1974, Weir and Richards 1974, Hoge 1977). The Red River Gorge area is within the watershed of the Red River, a tributary of the Kentucky River and part of the Ohio River drainage.

There are currently 90 known occurrences of *S. albopilosa* in Menifee, Powell, and Wolfe Counties, Kentucky, containing an estimated 45,000 stems (Kentucky Natural Heritage Program 1990; D. Fig, USFS, personal communication, 1990) (Figure 1). All 90 occurrences of *S. albopilosa* are within the proclamation boundary of the DBNF, which covers approximately 2,047,789 acres in Kentucky (669,379 acres owned by the Forest Service) (USFS 1985). The Red River Gorge Geological Area of the DBNF covers approximately 25,662 acres and contains 39 occurrences (Kentucky Natural Heritage Program 1990). The Clifty Wilderness of the DBNF, an 11,666-acre area within the eastern half of the Red River Gorge Geological Area, contains two occurrences of the species (Figure 2).

There may be additional occurrences of *S. albopilosa* in unexplored sandstone rock-shelters in the Red River Gorge area. Many of these rock-shelters are fairly remote and have not been explored by botanists. Other areas of the Cumberland Plateau and Shawnee Hills in Kentucky also have similar sandstone bedrock, which produces large cliffs with rock-shelters and ledges (Andreason and Eshbaugh 1973).

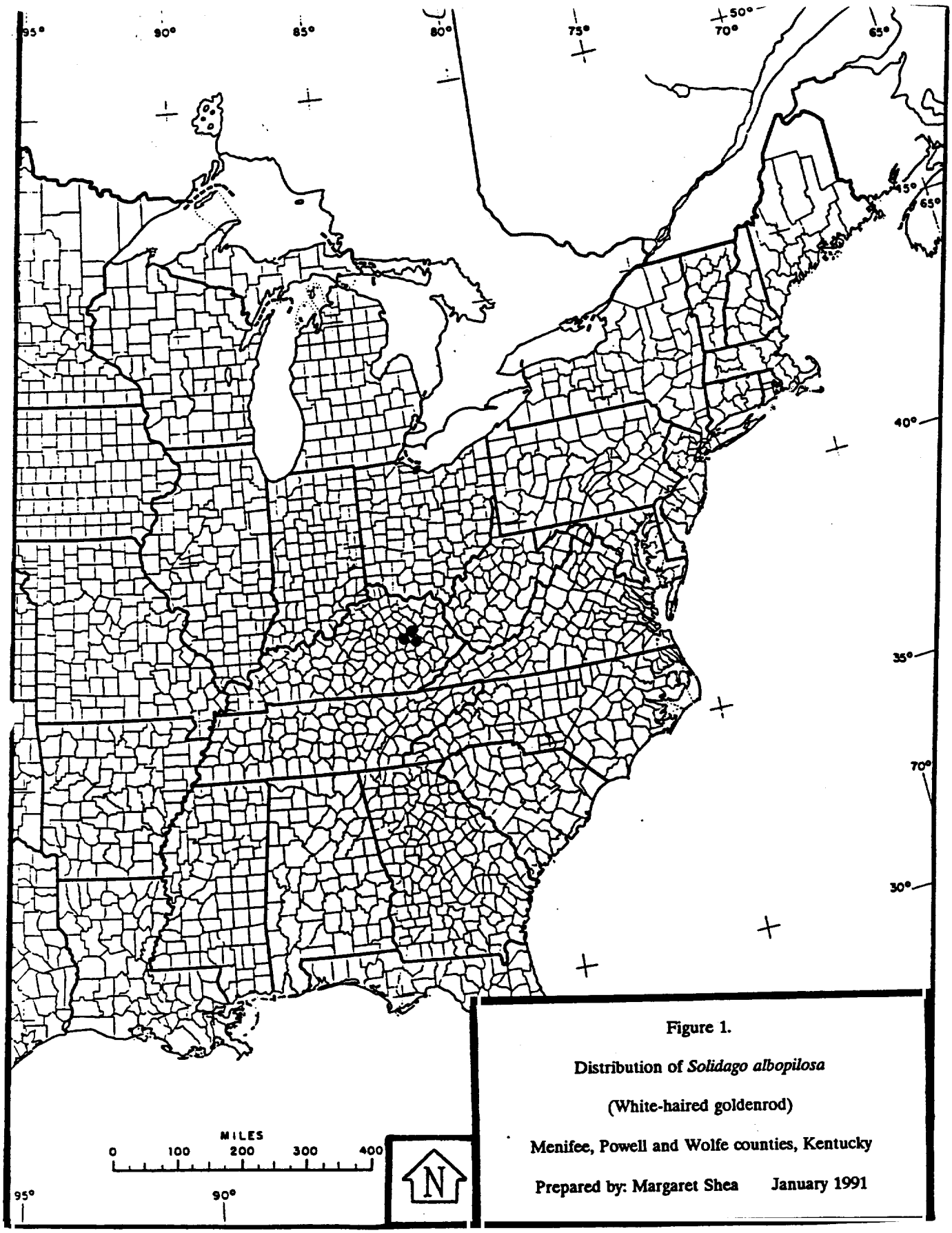

Figure 1.

Distribution of *Solidago albopilosa*

(White-haired goldenrod)

Menifee, Powell and Wolfe counties, Kentucky

Prepared by: Margaret Shea January 1991

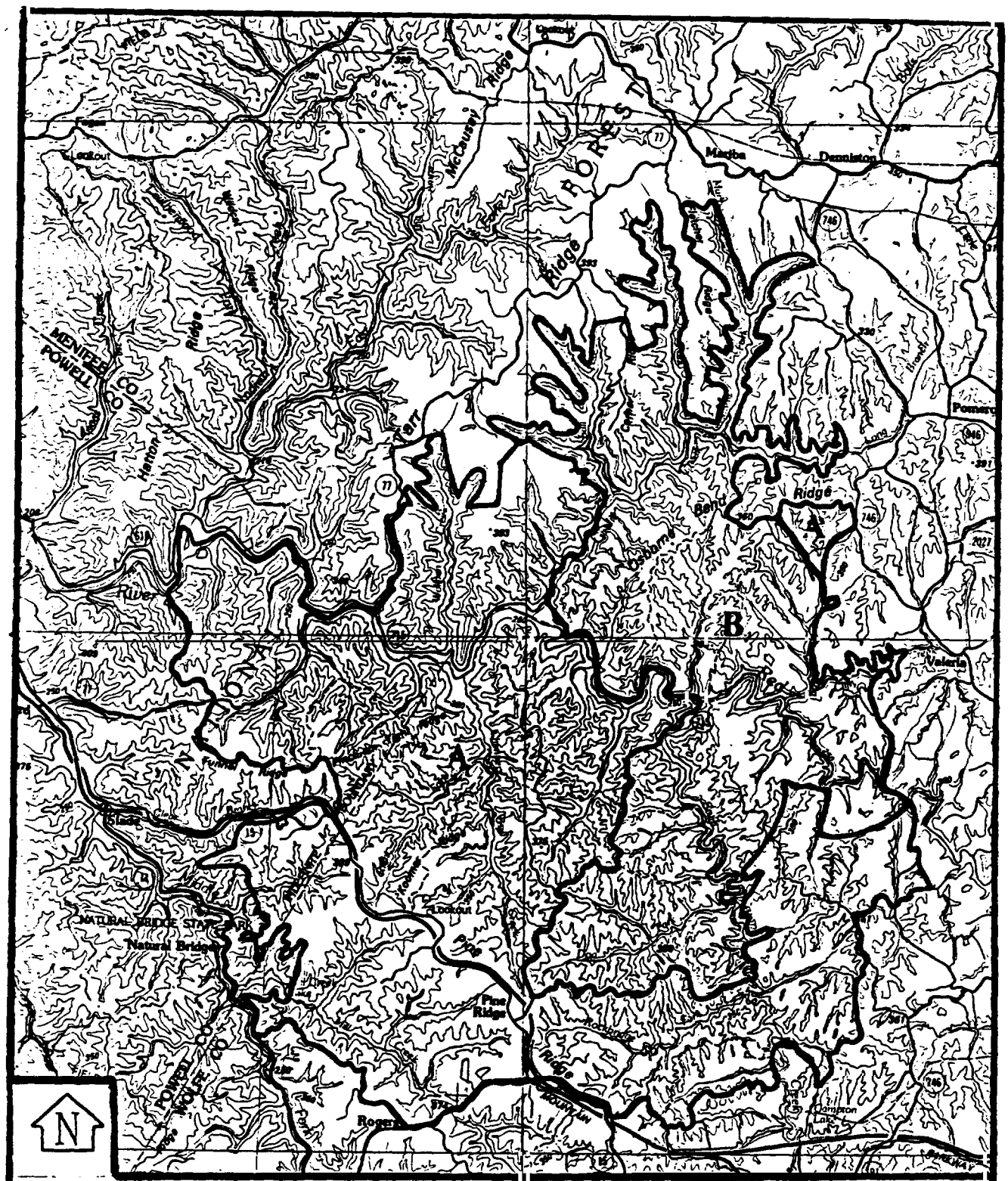

Figure 2. Map of (A) Red River Gorge Geological Area and (B) Clifty Wilderness. Irvine, Ky 30 X 60 Minute Quadrangle. Scale 1:100,000

It is possible that *S. albopilosa* is growing undiscovered in these other areas. Many other sandstone cliff areas have been searched by botanists, however, without finding *S. albopilosa*. Andreason and Eshbaugh argue that the absence of *S. albopilosa* in nearby suitable sites suggests it is a young species that has not spread far from its point of origin. They also propose that the opposite could be true; the limited range of *S. albopilosa* could indicate it is an old species existing as a relic in Kentucky.

Habitat

Solidago albopilosa grows in rock-shelters on the upper slopes of the Red River Gorge, between 800 and 1,300 feet mean sea level in elevation. There is no concentration of occurrences on any particular slope aspect (Campbell et al. 1989); however, plants in rock-shelters with north and northwest exposures are smaller than average, perhaps due to lower light levels or colder temperatures (Andreasen and Eshbaugh 1973). The species is usually found in the partial shade behind the drip line of rock-shelters; it does not grow in the furthest depths of the larger rock-shelters or in full sun (Harker et al. 1981). The species is occasionally found on rock ledges or in the sandy soil along the side of a trail.

Evidence suggests that *S. albopilosa* is not found under rock-shelters with unstable ceilings that drop large amounts of sand on the plants below (J. Varner, Georgetown College, personal communication, 1990). *Solidago albopilosa* plants weighted down by sand or water have lower seed production and seed viability than unaffected plants (Varner, personal communication, 1990). Rock-shelters protect the plants from direct rain except during the most severe storms. The species appears to thrive in dry sandy soil.

The soils of the DBNF can be divided into several categories--deep, loamy soils on alluvial bottoms and terraces (4 percent of the DBNF); moderately deep, gravelly, and stony loams on side slopes and deep, fine loamy soils in coves (73 percent of the DBNF); and moderately deep to deep loamy and clayey textured residual soils on ridges (23 percent of the DBNF) (USFS 1985). The soils in the portion of the DBNF where *S. albopilosa* is found are acidic, with a pH of 4.5 to 5.0 (Campbell et al. 1989).

The mean annual temperature for the Red River Gorge area of the DBNF is 55° to 56°F. Average July temperature is 76°F, and average January temperature is 35°F. The average annual precipitation is 46 to 48 inches, with 15 inches as snow (Campbell et al. 1989). Fall is usually the driest season; spring is the wettest.

Associated species found beneath rock-shelters include: *Actaea pachypoda, Adiantum pedatum, Arisaema triphyllum, Cornus florida, Dioscorea quaternata, Disporum lanuginosum, Heuchera parviflora, Hydrangea arborescens, Medeola virginiana, Microstegium vimineum, Mitchella repens, Pilea pumila, Polystichum acrostichoides,*

Rhododendron maximum, *Silene rotundifolia*, *Thalictrum clavatum*, *Toxicodendron radicans*, *Viburnum acerifolium*, and (rarely) *Trichomanes boschianum* (Braun 1942, Andreason and Eshbaugh 1973, Kral 1980, Campbell et al. 1989). Usually, nomenclature follows Kartesz and Kartesz (1980).

The DBNF is within the mixed mesophytic region of the Eastern Deciduous Forest (Braun 1950). Common woody species of the mesic forest adjacent to *S. albopilosa* occurrences include: *Acer rubrum*, *Acer saccharum*, *Aesculus octandra*, *Betula lenta*, *Fagus grandifolia*, *Hamamelis virginiana*, *Ilex opaca*, *Kalmia latifolia*, *Liriodendron tulipifera*, *Magnolia macrophylla*, *Magnolia tripetala*, *Nyssa sylvatica*, *Pinus strobus*, *Quercus* spp., *Rhododendron maximum*, *Tilia americana*, *Tilia heterophylla*, and *Tsuga canadensis* (Higgins 1968, Andreason and Eshbaugh 1973, Kral 1980, Campbell et al. 1989).

Life History

Solidago albopilosa flowers from September through November and sets fruit from mid-October through December. The flowers are reported to be visited by bees, which are probably attracted by the bright color and fragrance of the flowers (Braun 1942). There are also reports of syrphid flies visiting and possibly pollinating the flowers of *S. albopilosa* (J. MacGregor, USFS, personal communication, 1990). The viability of the species' pollen is reported to be high (89.2 percent) (Andreason and Eshbaugh 1973).

The presence of a fine pappus on the fruit of *S. albopilosa* suggests that it is primarily dispersed by wind. Germination of *S. albopilosa* seeds has not been studied; however, seeds of *S. flexicaulis*, a close relative, have reported germination rates of between 80 and 96 percent (Chmielewski et al. 1989). Seedlings of *S. albopilosa* have been seen in the field, indicating that the species can produce viable seed (D. Dourson, USFS, personal communication, 1990). Plants are rhizomatous, but the extent of vegetative reproduction is not known. *Solidago albopilosa* is reported to hybridize with *S. flexicaulis* (Braun 1942).

It is difficult to determine what constitutes a population of the species. The bees and syrphid flies that are reported to pollinate it likely carry pollen between nearby rock-shelters. These pollinators may also move between adjacent ravines. It is possible that all known occurrences of *S. albopilosa* are effectively one large population. Because further work is necessary to determine the population boundaries for the species, each cluster of plants within a single rock-shelter or on a single rock ledge is referred to as an occurrence in this plan.

Reasons for Listing

The primary threat to the survival of *S. albopilosa* is the many visitors to rock-shelters in the Red River Gorge area each year. In 1989, approximately 260,000 people visited the Red River Gorge Geological Area (Fig, personal communication, 1990). The Red River Gorge has an extensive trail system, and many of these trails pass through or near rock-shelters. Damage by visitors reached a peak in the 1970s (Fig, personal communication, 1990). During this period, 75 percent of the occurrences of *S. albopilosa* then known (to Varner) were severely damaged, and 11 occurrences (3,422 individuals) were extirpated (Varner, personal communication, 1990). One monitored occurrence declined from 415 stems to 85 stems, and another occurrence declined from 828 stems to 32 stems between the early 1970s and the mid-1980s (Varner, personal communication, 1990).

The heavy use of rock-shelters by hikers, campers, and rock climbers results in several types of damage to *S. albopilosa* individuals. Trampling can damage the current year's growth, or it can damage seeds. If trampling is severe, it may also damage the underground rhizomes, which often grow only 1 to 2 cm beneath the ground surface (D. Taylor, USFS, personal communication, 1990). Visitors also damage plants by dumping garbage and building fires in rock-shelters. Plants that were damaged by trampling and fire-building during heavy visitation in the 1970s recolonized these areas once they were left undisturbed (Fig, personal communication, 1990). In areas where disturbance continues for long periods, the plants may never recover. Other species of *Solidago* show reduced growth in compacted soil as compared to loose soil (Schmid and Bazzaz 1990). Even if plants are able to recolonize trampled areas, their growth may be stunted because of soil compaction or other mechanically induced alteration of the soil's structure.

Another serious threat to the species is digging by archaeological looters. Approximately half of the rock-shelters in this area were once inhabited by Indian tribes (C. Ison, USFS, personal communication, 1990). As looters dig up soil in their hunt for artifacts, they also dig up stolons and seeds of *S. albopilosa*. Plants may not recover from such extensive damage. All rock-shelters containing both *S. albopilosa* and Indian artifacts have been disturbed by looters (Ison, personal communication, 1990). Rock-shelter soils were also mined for saltpeter (potassium nitrate) in the past. It is possible that some occurrences of *S. albopilosa* were extirpated as a result of these activities.

Logging adjacent to *S. albopilosa* habitat could have a negative effect on this species. Logging near the rock-shelter habitat of *S. albopilosa* will increase light intensity and decrease water availability within the rock-shelters, possibly harming the plants. Logging could also allow weedy species to invade rock-shelters. These weedy species may compete with *S. albopilosa* plants and reduce

the size of occurrences (Kral 1980). The size of the buffer area needed to protect *S. albopilosa* from logging activities can best be determined by research directed to that end.

Of the 69 occurrences of *S. albopilosa* on Forest Service land, 39 are within the Red River Gorge Geological Area of the DBNF; 30 are outside of this managed area. The Red River Gorge Geological Area is not managed for timber production; however, there is some clearing of timber in these areas to promote wildlife (R. Wehner, USFS, personal communication, 1990). Two of the 39 Forest Service occurrences in the Red River Gorge Geological Area are also within the Clifty Wilderness of the DBNF. There is no logging within this portion of the forest. The 30 occurrences of *S. albopilosa* on Forest Service land within the DBNF but outside of the Red River Gorge Geological Area are in a portion of the forest that is actively managed for timber production. Logging is limited near these occurrences by current DBNF management policy (Taylor, personal communication, 1993). The ideal area of undisturbed forest buffer necessary to maintain healthy occurrences of the species is not known. Twenty-one occurrences are on private inholdings that have no restrictions on logging.

Occurrences of *S. albopilosa* on privately owned land are of special concern. It is difficult to prevent harmful activities in or near the species' habitat, including logging, archaeological looting, camping, and fire-building. Fifteen of the privately owned occurrences are on inholdings within the Red River Gorge Geological Area; however, this does not provide these occurrences with any protection against logging (Dourson, personal communication, 1990).

Construction of a dam on the Red River by the U.S. Army Corps of Engineers was authorized in 1962. This project was placed in an "inactive" category in 1976 because the Commonwealth of Kentucky withdrew its support (U.S. Army Corps of Engineers 1987). In the event that work on this project is reinitiated, the impact of the dam on the species should be considered. Construction of the proposed dam would not flood any of the known *S. albopilosa* occurrences, all of which are found at elevations greater than 800 feet mean sea level. The pool level of the proposed lake would be at 703 feet mean sea level; the flood level would be at 759 feet mean sea level (U.S. Army Corps of Engineers 1987). The presence of a lake near the plants could change the temperature and humidity of the area. A reservoir in the Red River Gorge could attract more visitors, which could lead to more trampling of plants.

Solidago albopilosa plants are sometimes damaged by herbivores, although this does not seem to be a serious threat at this time. Herbivores known to damage the species include woodrats and caterpillars (Dourson, MacGregor, and Taylor; personal communications; 1990). Significant damage by herbivores was observed within one population, with all leaves removed from approximately half the plants (M. Shea, Kentucky State Nature Preserves Commission,

personal communication, 1990). It is not known what caused this damage.

Solidago albopilosa is reported to hybridize with *S. flexicaulis* (Braun 1942).

Conservation Measures

A number of actions have already been taken to help ensure the survival of *S. albopilosa* occurrences. The logging policy for Forest Service land is designed to protect *S. albopilosa* from the immediate effects of logging. The two occurrences of *S. albopilosa* within the Clifty Wilderness are protected from logging because it is not permitted within this portion of the forest (Wehner, personal communication, 1990). The remaining 67 occurrences that are on Forest Service land are protected from nearby logging by the Forest Service's current endangered and threatened species management policy (Taylor, personal communication, 1993). A portion of this policy is specifically aimed at protecting rare or sensitive cliff-line plants. This policy prohibits logging from the base of the cliff downslope to the nearest break in the slope or to 50 feet from the drip line. It also requires that the forest above the cliff be maintained as needed to protect the site's hydrologic characteristics. It is important that the Forest Service continue this policy and incorporate it into the management plan for the DBNF.

Twenty-one occurrences of *S. albopilosa* are on privately owned land within the DBNF. The seven landowners who have the species on their property were contacted in the early 1980s and were informed of the need to protect the species (Fig, personal communication, 1990). Work is being done by the Forest Service to purchase the land ranked here as number 6 (Table 1) (Fig, personal communication, 1990). This tract is being purchased because of an archaeological site on the property.

Table 1. Rank of privately owned *Solidago albopilosa* occurrences. Rank based on number of stems, number of occurrences, and condition.

Current Rank	Number of Occurrences	Number of Stems	Condition
1	2	3,000	Good
2	1	3,000	Good
3	12	2,000	Good
4	1	2,000	Good
5	1	200	Good
6	3	30	Good
7	1	"nearly extirpated"	Poor

Work has been done to protect the plants from digging, trampling, and fire-building. Signs were put up in 1985 at all entry points to the Red River Gorge Geological Area asking visitors not to remove or disturb historical resources. Signs with a similar message were placed inside all major rock-shelters that are archaeologically significant, including an estimated five rock-shelters that contain *S. albopilosa* (Fig, personal communication, 1990). These signs had little effect, however, and the digging and removal of artifacts continues (Ison, personal communication, 1990). The Forest Service is also developing a sign to be posted along cliff lines within the DBNF (Dourson, personal communication, 1990). This sign will inform hikers of the rare species along the cliffs and request that they not camp or build fires within rock-shelters.

Strategy of Recovery

The impact that humans have on the rock-shelter habitat is the most severe threat to the continued existence of *S. albopilosa*. Work must be done immediately to prevent damage from trampling, fire-building, and archaeological looting. A number of occurrences should be fenced to ensure that they are protected from human activities. In addition, the Forest Service should adopt and enforce a policy that forbids camping and fire-building within rock-shelters. Signs should be placed at all occurrences informing hikers and campers of this policy, and additional rangers should be hired to patrol the area and enforce the policy. Trails that lead to rock-shelters containing *S. albopilosa* should be rerouted to reduce the number of visitors to this vulnerable habitat. Remote sensors could be placed in rock-shelters containing both archaeological artifacts and *S. albopilosa* plants in order to deter looters, and patrols in these areas could be increased. If looters are caught and punished, future digging damage may decline.

The current number of individuals and the level of damage in all occurrences of the species should be determined and included in an updated status survey for *S. albopilosa*. Permanent plots should be established, and long-term demographic studies should be used to gain an understanding of the growth and reproduction of occurrences and to monitor changes in their size and vigor. Any decline can be detected early if occurrences are checked regularly.

Information about *S. albopilosa* should be disseminated to the public to increase their awareness of the species, the threats to its survival, and the work that is being done to protect it.

More information is needed regarding the physical requirements of *S. albopilosa* in order to appropriately manage areas for the optimal growth and reproduction of the species. Studies should be done to determine its light, moisture, and soil requirements. This information could be used to restore appropriate conditions to sites that have been altered and to reestablish plants in extirpated sites.

The search for additional occurrences of *S. albopilosa* should continue, especially in the most remote regions of the Red River Gorge, where human impact is minimal. Also, studies of the population biology of *S. albopilosa* are needed to provide information that can be used to develop appropriate management strategies for the species.

All occurrences of *S. albopilosa* need to be protected from nearby logging. It is important that private owners of *S. albopilosa* sites are contacted and informed of the presence of the species on their property and that an attempt is made to protect these lands from uses that are harmful to the species. Legal protection, such as management agreements, conservation easements, acquisition, and dedication, should be used to protect these areas.

On Forest Service land, the merits of designating specific Research Natural Areas, Botanical Areas, or Special Management Areas should be evaluated. The adequacy of the current DBNF white-haired goldenrod management policy to provide a sufficiently large buffer area of uncut forest around the species' occurrences should be determined and modified if necessary.

PART II

RECOVERY

A. Recovery Objectives

Solidago albopilosa will be considered for delisting when 40 geographically distinct, self-sustaining occurrences are adequately protected and have been maintained for 10 years. An occurrence will be considered to be adequately protected when it is legally protected, has received adequate physical protection, and is assured of all required management. An occurrence will be considered to be self-sustaining if there is evidence of successful reproduction and the number of individuals is stable or increasing. The requirements for delisting are preliminary and may change as more information about the biology of the species is discovered.

B. Narrative Outline

1. Protect existing occurrences. Specific actions can and must be taken to reduce the impact of threats to the species. Information from studies on the life history and ecology of *S. albopilosa* (Task 3) and further inventory work (Task 2) will provide additional information about threats to the species. Recovery actions should be modified as new information is acquired.

1.1 Protect occurrences from trampling. Trampling is the most significant threat to *S. albopilosa*. If left unchecked, trampling could lead to the significant decline of the species. Damage from trampling reached a peak during the late 1970s, when controversy over the U.S. Army Corps of Engineers' proposed dam in the Red River attracted many curious visitors to the area (Fig and Varner, personal communications, 1990). Although damage to plants by trampling has decreased somewhat since that time, it is likely that visitation will increase in the future.

1.1.1 Divert trails from *S. albopilosa* occurrences. Trails on Forest Service land that are adjacent to rock-shelters containing significant *S. albopilosa* occurrences should be rerouted in order to make these rock-shelters less accessible. The original trail should be covered with brush. This will make access to the rock-shelters more difficult and may reduce visitation. The decision to reroute a trail will be made on a site-specific basis. Within all rock-shelters where *S. albopilosa* grows, trails should be created and clearly outlined for those hikers who still manage to reach them. A defined trail may help to restrict damage to a localized area.

1.1.2 Develop and enforce a "no camping" and "no fire" policy for rock-shelters if determined appropriate. There is currently no policy on Forest Service land that forbids camping in rock-shelters, and the policy that prohibits fires within rock-shelters is not enforced. The need for such a policy should be evaluated and implemented if it is determined to be appropriate. There should be a clearly stated and strictly enforced policy prohibiting both camping and fires within rock-shelters. This policy should be stated on posted signs (Task 1.1.3) and on maps of the Red River Gorge area (Task 5). Enforcement of the policy should be

vigorous in order for it to be effective in protecting the species.

1.1.3 Place signs to protect *S. albopilosa* habitat. Signs notifying the public of the fragile nature of the rock-house habitat should be posted at appropriate locations. The effectiveness of placing the signs at strategic locations along trails and at trail heads versus placing them at important rock-shelters should be evaluated. Signs should also state that camping and fire-building are prohibited within the rock-shelters (Task 1.1.2). The signs should request that visitors stay on the trail (Task 1.1.1). The vigor of occurrences should be monitored in order to determine the effectiveness of the signs. The projected cost of this work will be greater if signs need to be replaced because of vandalism.

1.1.4 Fence occurrences of *S. albopilosa*. In order to evaluate the effectiveness of this protection mechanism, several occurrences of *S. albopilosa* should be fenced. A number of criteria should be used to determine which occurrences will be fenced. The fenced occurrences should be distributed across the range of the species. Fences should be used to protect occurrences that are damaged from trampling or digging but are likely to survive. It may be appropriate to implement this strategy in stages that permit an evaluation of the technique prior to the expenditure of large amounts of money. If other management to prevent trampling of the species is not effective and it is determined that fencing is successful, additional occurrences should be fenced.

1.2 Evaluate the need to use remote sensors to discourage archaeological looting. All rock-shelters containing both *S. albopilosa* and archaeological artifacts have been disturbed by looters (Ison, personal communication, 1990). Looting for archaeological artifacts severely disturbs the soil and is likely to destroy the rhizomes of *S. albopilosa*. The efficacy of placing remote sensors in rock-shelters that are both archaeological sites and that provide *S. albopilosa* habitat should be evaluated. These sensors will detect metal, movement, or sound within a rock-shelter and set off an alarm at a monitoring station. This alarm system will help in apprehending and prosecuting looters. If it is determined that this is an effective and efficient means

of protecting rock-shelters, the technique should be used, where necessary, to effect the needed protection.

1.3 Establish protected areas. Logging adjacent to rock-shelters will increase the amount of light and could increase the number of weedy species within the rock-shelters. Logging near the *S. albopilosa* occurrences on Forest Service land should be restricted in order to prevent changes in the environment that could be harmful to the species. Two occurrences within the Clifty Wilderness are protected from any nearby logging (Wehner, personal communication, 1990). The remaining 67 occurrences are protected from logging immediately adjacent to the rock-shelter by Forest Service policy. Future research will determine whether current policy adequately protects *S. albopilosa*. The merits of using Research Natural Areas, Botanical Areas, or Special Management Area designations to protect specific occurrences should be evaluated and utilized if appropriate. Management plans should be developed for these protected areas once they are established and should stipulate that there be no logging within them. Occurrences within these protected areas should be monitored and compared to occurrences that are outside of these areas in order to evaluate the effectiveness of the current policy (Task 3.1). If the current policy is determined to be insufficient, the policy should be rewritten to allow for a larger buffer, and/or more protected areas should be established. If the policy is found to be adequate, it should be written into the management plan for the DBNF. The cost of this work will depend on the type of protection chosen.

1.4 Ensure that the species is protected if a dam is constructed on the Red River. The U.S. Army Corps of Engineers proposed damming the Red River in 1962. The plan met heavy opposition and was later put on an "inactive" list. A dam on the Red River would result in increased traffic to the area, which could result in more trampling damage to *S. albopilosa* occurrences. The presence of a nearby lake would also alter the climate of the Red River Gorge area, which could have a negative effect on *S. albopilosa* plants. If planning for this project is reinitiated, protection of the species should be incorporated into the planning process.

1.5 Reintroduce plants into appropriate habitat. If occurrences of *S. albopilosa* continue to decline despite other management efforts, plants from healthy occurrences or plants grown *ex situ*. should be transplanted in order to enhance dwindling occurrences and reestablish extirpated occurrences.

1.6 Determine the ownership of populations that occur on private land and contact the owners. Of the 90 known occurrences of *S. albopilosa*, 21 are on privately owned land. Current information should be gathered on all privately owned tracts of land where *S. albopilosa* occurs. Landowners should be contacted and informed that a federally threatened plant is found on their property. Landowners should also be informed of the threats to the species and actions they can take to increase the species' chance of survival.

1.7 Establish the highest level of protection for occurrences on private land. Protection of land where *S. albopilosa* grows should be aimed at preventing logging, camping, fire-building, and all other outlined threats to the species. The level of protection appropriate for each occurrence of *S. albopilosa* should be determined based on the size and vigor of the occurrence and the quality of its habitat. Meetings should be held with landowners to negotiate the desired level of protection. Possible types of legal protection for the land include management agreement, conservation easement, acquisition, and dedication. Dedication as a State nature preserve is the highest possible legal protection for a tract of land within the Commonwealth of Kentucky. An additional type of protection is the registration of an area on the Kentucky Natural Areas Registry. This can be useful as a temporary means of protecting a site; however, it is not permanent or binding on a landowner. The Kentucky State Nature Preserves Commission, a State agency, administers the dedication and registration programs. Based on current information, these privately owned occurrences should be protected in the order of the "current rank" listed in Table 1. The cost of this work will depend on the type of protection selected for these areas. The acquisition of land will greatly increase the cost of protection.

2. Continue inventory. A 1980 status survey reported 37 occurrences of *S. albopilosa* (Medley 1980). Since then, 53 additional occurrences have been discovered. To develop an appropriate management plan for *S. albopilosa*, it is important to have the most accurate information possible on its range and number of occurrences.

2.1 Update the status survey. The 1980 status survey for *S. albopilosa* indicated that only 2 of 37 rock-shelters containing *S. albopilosa* appeared to be free of human damage. The number of known occurrences of the species has more than doubled since 1980. In order to prevent the extinction of the species, it is important that the present condition of all occurrences of *S. albopilosa* is

known and that immediate work is begun to protect the most threatened occurrences.

2.2 Search for new occurrences in Red River Gorge rock-shelters. The Red River Gorge area should be explored more carefully to determine whether there are additional occurrences of *S. albopilosa*. Top priority should be put on rock-shelters that are far from marked trails. These remote rock-shelters will receive less human traffic, and any occurrences of *S. albopilosa* in them may be more likely to survive. The Clifty Wilderness of the DBNF should be searched first because this area offers the greatest legal protection.

2.3 Search for new occurrences in other regions of Kentucky. Other locations in Kentucky with Pottsville formation sandstone rock-shelters should be searched to see if the known range of the species can be extended. Andreasen and Eshbaugh (1973) report that Pottsville formation sandstone is also found in other places within the Cumberland Plateau section of the Appalachian Plateaus Physiographic Province and in the Shawnee Hills section of the Interior Low Plateaus Physiographic Province. Likely locations within these regions should be searched for *S. albopilosa*. An occurrence from another region may be genetically different. New genotypes may be important in future management because transplants between occurrences may become necessary if occurrences become small and inbred.

3. Conduct studies on life history and ecological requirements. There is very little information on the ecology and life history of *S. albopilosa*. An understanding of the biotic and abiotic interactions that occur in a healthy occurrence will help determine the appropriate steps for recovery. Regular monitoring of occurrences may prevent their extirpation because, if a decline is observed, action can be taken before the occurrence disappears. If reintroduction of extirpated occurrences becomes necessary in the future, a basic knowledge of the species' life history will aid in reestablishing the occurrence.

3.1 Set up permanent plots. Permanent 1-m^2 plots should be set up in an adequate sample of rock-shelters where the species occurs. Plots should be established in both disturbed and undisturbed rock-shelters. Large nails placed flush to the ground should be used to mark the corners of the plots. This type of marker is inconspicuous and less likely to be vandalized. Distance to the plot should be measured from two known landmarks so that relocating the plots is easy. These plots will be used to study demography (Task 3.2), the

physical habitat (Task 3.3), flowering phenology and pollination biology (Task 3.4.1), and herbivores (Task 3.5). Work within these plots should be restricted to nonmanipulative observations. The plots will enable long-term observations on the condition of selected occurrences. These constant observations are necessary to monitor damage to the occurrences and prevent the extinction of the species.

3.2 Conduct long-term demographic studies. Permanent plots should be monitored several times annually to learn more about the demography of the species. Individual stems should be marked with small nails and should be measured annually so that the growth, mortality, and recruitment of new stems can be observed. In order to determine the relative importance of vegetative and sexual reproduction, new stems should be observed to determine whether they are seedlings or shoots from rhizomes. Annual censuses will indicate whether occurrence size is increasing or declining. The number of flowering stems should be recorded each year in order to monitor changes in reproductive output over a period of time. If these observations indicate a decline in the recruitment of new individuals or a decline in the number of flowering individuals in an occurrence, attempts should be made to promote reproduction within the occurrence. These frequent observations are necessary to prevent the extinction of the species.

3.3 Analyze habitat requirements. The physical requirements of the species should be determined in order to better understand its distribution and predict the effect of changes in the environment on plant vigor. Because many occurrences are severely disturbed, artificial propagation or reintroduction of the species into appropriate habitat may be necessary for its future survival. Knowledge of the habitat requirements of the species is therefore essential to prevent its extinction.

3.3.1 Determine soil characteristics. Soils that support *S. albopilosa* should be analyzed for texture, pH, mineral composition, organic content, and soil moisture. Soil samples should be taken adjacent to the permanent plots. Soil samples should also be taken from the floor of an equal number of rock-shelters that do not contain *S. albopilosa*. Comparisons should be made to determine whether there are any significant differences in the soil.

3.3.2 Determine optimal moisture and light levels. Seeds should be collected and grown in an experimental garden under different levels of moisture and light in order to determine the optimal levels of these factors. Light and moisture levels should also be measured within rock-shelters where *S. albopilosa* grows and should be compared to light and moisture levels in nearby rock-shelters where the species is not found.

3.4 Study the species' reproduction. The reproductive biology of *S. albopilosa* should be studied in order to understand the physical and biological factors necessary for the species to reproduce.

3.4.1 Investigate flowering phenology and pollination biology. Observations should be made on the timing of flower and fruit production for individual stems within the permanent plots (Task 3.1). Insect visitors to *S. albopilosa* flowers need to be observed at all times of the day. The abundance of other bee-pollinated species within the permanent plots should be measured. The presence of other species' flowers may attract more pollinators to the area and to the *S. albopilosa* plants. If pollinators are rarely seen visiting certain occurrences, supplemental pollination of plants in these occurrences may be necessary to promote sexual reproduction. Insects should be collected for identification and to determine whether they are carrying *S. albopilosa* pollen. Flowers should be probed for nectar, and the quantity and concentration produced should be measured. Controlled pollinations should be performed to determine whether viable seeds can be produced by self-pollination. The percent of flowers that produce seeds when self-pollinated should be compared with open-pollinated flowers. These controlled pollinations should be performed outside of the rock-shelter containing the permanent plots. Plants in three rock-shelters that are well distributed over the range of the species should be used for this experiment.

3.4.2 Study seed bank, seed dispersal, seed viability, and germination. Soil samples should be taken from an area near the permanent plots and should be placed in a greenhouse to determine the number of viable seeds present. Samples should also be taken from areas where *S. albopilosa* has been

extirpated to determine whether the species can recolonize an area through the seed bank and through rhizomes present in the soil. Seeds should be collected from as many different occurrences as possible, and the conditions necessary to break dormancy should be determined. The percentage of viability in seeds should be determined, and comparisons should be made between occurrences. If there are significant differences in seed viability between occurrences, further work should be done to determine the attributes of occurrences that affect seed viability. Seed traps should be placed on bare ground at various distances from *S. albopilosa* plants in order to determine the distance the seeds travel. Traps should also be placed in rock-shelters that do not contain *S. albopilosa* but adjacent to rock-shelters where the species is found.

3.4.3 Study the hybridization of *S. albopilosa* with *S. flexicaulis* and *S. flaccidifolia*. Controlled pollinations should be performed with *S. albopilosa*, *S. flexicaulis*, and *S. flaccidifolia* in order to determine whether they can successfully hybridize. Seeds produced by these crosses should be germinated to determine whether they can produce fertile plants. These crosses should be performed in the greenhouse in order to avoid introducing artificially produced hybrids into the wild. Known populations of *S. albopilosa* should be carefully studied for evidence of naturally occurring hybrids. If it is determined that hybridization constitutes a threat to any significant population, a plan to deal with that threat should be developed and implemented.

3.5 Determine impact of herbivores. The level and impact of herbivores on the growth and reproduction of individual plants should be monitored within permanent plots. Yearly observations should be made of the species for animals seen feeding on plants, the number of plants damaged, and the extent of damage to each plant. Growth and reproductive output of damaged and undamaged plants should be compared. It is necessary to determine the extent of herbivore damage to the species before any decisions are made regarding management to reduce impacts by herbivores. If herbivores are seen to have a significant impact on the growth and reproduction of *S. albopilosa*, work must be done to keep them away from the species.

3.6 Determine the impact of competition. The effect of competition among *S. albopilosa*, other rock-shelter plant species, and potential invasive weeds should be determined. If other species have a significant effect on the growth and reproduction of *S. albopilosa*, they may have to be thinned in order to maintain healthy *S. albopilosa* occurrences. Experiments should be done in a greenhouse to study the importance of these competitive interactions.

3.7 Determine genetic variability. Electrophoresis should be used to determine the degree of genetic variability among individuals in the same rock-shelter and between individuals in different rock-shelters. Information on naturally occurring genetic variability will help in determining the appropriate methods for reintroducing plants (Task 1.5) while still maintaining genetic diversity. The degree of genetic difference between occurrences will also help to determine the boundaries of *S. albopilosa* populations.

4. Maintain plants and seeds *ex situ*. In order to protect the species against a catastrophic event, seeds and plants from several occurrences should be maintained *ex situ*. Seeds should be collected from several occurrences so that the genetic diversity of the species is represented. Available plants and seeds could be used to reintroduce the species into its habitat if existing occurrences disappear. These protected plants and seeds could also be used as sources of plants for studies on the population biology of the species.

4.1 Deposit seeds into a seed bank. Seeds from several occurrences should be collected and sent to the U.S. Department of Agriculture's Agricultural Research Service National Seed Storage Laboratory in Ft. Collins, Colorado.

4.2 Maintain plants *ex situ*. *Solidago albopilosa* plants should be grown and maintained at botanical gardens affiliated with the Center for Plant Conservation.

5. Provide the public with information. Because trampling by humans is the greatest threat to *S. albopilosa*, it is essential to its continued survival that the public is educated about the species, the damage being done, and what they can do to prevent further damage. Distributing information within the DBNF should be the first approach. Posting signs at all significant rock-shelters and/or along trails was discussed in Task 1.1.3. Information about the species and the damage being done should also be included in hiking maps of the area. Local newspapers and newspapers from surrounding cities should be provided with information about the species.

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PART III

IMPLEMENTATION SCHEDULE

Priorities in column one of the following Implementation Schedule are assigned as follows:

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. Priority 2 - An action that must be taken to prevent a significant decline in the species' population, habitat quality, or some other significant negative impact short of extinction.

3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

FWS - U.S. Fish and Wildlife Service
TE - Endangered Species Division of the U.S. Fish and Wildlife Service
LE - Law Enforcement Division of the U.S. Fish and Wildlife Service
PA - Public Affairs Office of the U.S. Fish and Wildlife Service
COE - U.S. Army Corps of Engineers
CPC - Center for Plant Conservation
FS - U.S. Forest Service
KNPS - Kentucky Native Plant Society
KSNPC - Kentucky State Nature Preserves Commission
TNC - The Nature Conservancy
UK - University of Kentucky
USDA - U.S. Department of Agriculture

WHITE-HAIRED GOLDENROD IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000's) FY1	FY2	FY3	Comments
1	1.1.1	Divert trails.	1 year	R4/TE	FS	9.0	---	---	Three people working 4 weeks.
1	1.1.2	Restrict activities in rock-shelters.	Continuous	R4/TE, LE	FS	3.6	3.6	3.6	Expenses for law enforcement--one person working 2 days per month.
1	1.1.3	Post signs to protect rock-shelters.	1 year	R4/TE	FS	6.0	---	---	Two people working 2 weeks; $3K for signs.
1	1.1.4	Fence populations.	1 year	R4/TE	FS	55.0	---	---	Three people working 4 weeks; $5K for fencing (ten 100-foot-long, 7-foot-tall sections with posts and cement).
1	1.4	Ensure species' protection if Red River is dammed.	Ongoing	R4/TE	COE, FS, KSNPC	---	---	---	
1	2.1	Update status survey.	1 year	R4/TE	FS, KSNPC, TNC	4.5	---	---	One person working 6 weeks.
1	3.1	Set up permanent plots.	1 year	R4/TE	FS, KSNPC	1.0	---	---	One person working 1 week; $0.25K for equipment.
1	3.2	Long-term demographic studies.	Continuous	R4/TE	FS, KSNPC	0.75	0.75	0.75	One person working 1 week.

WHITE-HAIRED GOLDENROD IMPLEMENTATION SCHEDULE (continued)

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Other	Cost Estimates ($000's) FY1	FY2	FY3	Comments
1	3.3.1	Determine soil characteristics.	1 year	R4/TE	FS, KSNPC	1.0	---	---	One person working 3 days; $0.5K for equipment.
1	3.3.2	Determine optimal light and moisture levels.	1 year	R4/TE	FS, KSNPC	3.5	---	---	Field work: One person working 1 week. Greenhouse study: One person working 3 weeks; $0.5K for equipment.
1	4.2	Maintain plants *ex situ*.	Continuous	R4/TE	CPC, FS, UK	6.9	---	---	One person working 2 days collecting seeds; $6.6K for permanent maintenance.
1	5	Provide public with information.	Continuous	R4/TE, PA	FS, KNPS, KSNPC, TNC	0.75	0.75	0.75	One person working 1 week per year.
1	1.2	Evaluate the need to place remote sensors in rock-shelters with artifacts and *S. albopilosa*.	Continuous	R4/TE	FS	11.1	3.6	3.6	$7.5K for three sensors. $3.6K for labor each year (one person, 24 days per year).
2	1.3	Establish protected management areas.	1 year	R4/TE	FS	26.0	---	---	One person working 8 weeks; cost of surveys estimated at $20K.

WHITE-HAIRED GOLDENROD IMPLEMENTATION SCHEDULE (continued)

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000's) FY1	FY2	FY3	Comments
2	1.6	Determine ownership and contact.	1 year	R4/TE	KSNPC, TNC	1.0	---	---	One person working 6 days.
2	1.7	Determine and negotiate highest level of protection.	3 years	R4/TE	FS, KSNPC, TNC	22.5	22.5	22.5	One person working 3 weeks per year. Estimated cost for acquisitions $60K.
2	2.2	Search for new occurrences in Red River Gorge area.	2 years	R4/TE	FS, KSNPC, TNC	3.0	3.0	3.0	One person working 4 weeks each year. Incorporate with Tasks 2.1 and 3.2.
2	2.3	Search for new occurrences in other areas of Kentucky.	1 year	R4/TE	KSNPC	3.0	---	---	One person working 4 weeks.
2	3.4.1	Study phenology and pollination biology.	1 year	R4/TE	FS, KSNPC	2.0	---	---	One person working 2 weeks; $0.5K for equipment.
2	3.4.2	Study seed bank, transport, viability, and germination.	3 years	R4/TE	FS, KSNPC	3.0	0.75	0.75	One person working 5 weeks over a 3-year period; $0.75K for equipment.
2	3.5	Determine impact of herbivores.	3 years	R4/TE	FS, KSNPC	0.5	0.5	0.5	One person working 2 weeks over a 3-year period (incorporate with Task 3.2).

WHITE-HAIRED GOLDENROD IMPLEMENTATION SCHEDULE (continued)

Priority	Task Number	Task Description	Task Duration	Responsible Agency FWS	Responsible Agency Other	Cost Estimates ($000's) FY1	FY2	FY3	Comments
2	3.6	Determine impact of competition.	1 year	R4/TE	FS, KSNPC	3.5	---	---	One person working 4 weeks; $0.5K for equipment (incorporate with Task 3.2).
2	3.7	Determine genetic variability.	1 year	R4/TE	FS, KSNPC	4.0	---	---	One person working 4 weeks; $1K for equipment.
3	1.5	Reintroduce plants into appropriate habitat if necessary.	1 year	R4/TE	CPC, FS, KSNPC	---	---	---	One person working 2 weeks; $1.5K some time in the future.
3	4.1	Collect and deposit seeds into seed bank.	1 year	R4/TE	CPC, FS, KSNPC, USDA	0.3	---	---	One person working 2 days collecting seeds.

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